FACT SHEET

Threat Ensemble Vulnerability Assessment (TEVA) Computational Framework

Background

EPA's National Homeland Security Research Center (NHSRC), Water Infrastructure Protection Division (WIPD), headquartered in Cincinnati, Ohio, conducts and coordinates research to improve the security of drinking water and wastewater treatment systems.

To counter threats against water systems, NHSRC is developing the Threat Ensemble Vulnerability Assessment (TEVA) program. This program uses a computational framework containing a suite of software tools that can simulate threats and identify vulnerabilities in drinking water distribution systems, measure potential public health impacts, and evaluate mitigation and response strategies.

The TEVA Modeling Program

The Threat Ensemble Vulnerability Assessment (TEVA) program was initiated by EPA in order to thoroughly study contamination threats to drinking water systems and use the information gained to design monitoring and surveillance systems and other mitigation methods for preparing for, and responding to, contamination attacks on drinking water systems.

The main goals of TEVA are:

1. To develop, optimize, and make available to water utilities a suite of software tools for drinking water distribution system security.
2. To use the TEVA system to design, implement, and test a contamination monitoring system in a utility distribution system.

TEVA uses EPA's freely available EPANET software program to simulate hydraulic and water quality behavior in pipe networks. The TEVA computational framework contains several additional modules that enable the user to perform:

- Consequence assessment
- Sensor placement and cost analyses
- Evaluation of mitigation strategies
- Response planning

Given a utility-specific hydraulic model, the TEVA computational framework can be used to assess the potential health impacts resulting from a variety of contamination scenarios; design and evaluate possible mitigation strategies, such as a contaminant warning system; and plan effective response activities, such as containment and public health intervention.

Consequence Assessment
TEVA uses the EPANET hydraulic and water quality model, as well as the multi-species modules for EPANET, to simulate the fate and transport of contaminants in distribution systems. By considering the uncertainty of potential contamination scenarios, TEVA calculates the statistical distribution of potential health impacts. Consequences of the contamination are estimated by predicting the public health impacts resulting from the ingestion of contaminated water. Using a probabilistic model for ingestion, contaminant-specific dose-response models, and dynamic models for disease progression over time, TEVA can predict the expected health impacts.

Mitigation Strategies
TEVA focuses on designing contaminant warning systems to mitigate the effects of contamination events. Contaminant warning systems collect information from online sensors to provide an early warning of a contamination event and to reduce the public health or economic impacts. Many of the TEVA collaborators have developed methods for locating sensors in distribution systems (Uber, 2004b; Berry, 2003, 2004; Watson, 2004). The TEVA computational framework offers several options for optimally locating sensors and allows for the comparison of costs and benefits of various sensor network designs.

Planning and Response
Ultimately, the TEVA computational framework will include capabilities for real-time response to contamination, including inverting sensor data to determine the location of the contamination source; planning response activities such as isolation and containment; and designing treatment, decontamination, and confirmatory sampling strategies.

TEVA Collaborators and Partners
The software modules that make up the TEVA computational framework are being developed in collaboration with researchers at the University of Cincinnati, Sandia National Laboratories in Albuquerque, New Mexico, and Argonne National Laboratory in Chicago, Illinois.

EPA partnered with the American Water Works Association (AWWA) to form a Water Utility Users Group made up of AWWA member utilities. EPA has entered into Memoranda of Understanding with a subset of Users Group participants to enable the sharing of network and threat information. The TEVA computational framework modules will be tested against these utility models.

Multiple Benefits
The TEVA computational framework is expected to be used for many applications in addition to water security. In particular, the software can model accidental contamination incidents resulting from backflow, cross-connection, and permeation or leaching from system

components and can design monitoring networks to detect such contaminants. The software may be useful for determining sampling points for routine compliance monitoring.

TEVA Products

A preliminary version of the software is expected to be available for research purposes by the end of 2006. TEVA program products include the following journal and conference reports:

Berry, Jon, William Hart, and Cynthia Phillips, "Locating Sensors in Municipal Water Networks," Proceedings of the ASCE/EWRI Congress, 2003.

Berry, Jon, et al., "A General Integer Programming Based Framework for Sensor Placement in Municipal Water Networks," Proceedings of the ASCE/EWRI Congress, June 2004.

Berry, Jon, et al., "Sensor Placement in Municipal Water Networks," to appear in *Journal of Water Resources, Planning, and Management*, 2005.

Janke, Robert, Jim Uber, Regan Murray, and Steve Allgeier, "Evaluating the Costs and Benefits of Monitoring Strategies for Drinking Water Contaminants," Proceedings of the ASCE/EWRI Congress, May 2005.

Murray, Regan, Robert Janke, and James Uber, "The Threat Ensemble Vulnerability Assessment Program for Drinking Water Distribution System Security," Proceedings of the ASCE/EWRI Congress, 2004.

Murray, Regan, Jim Uber, and Robert Janke, "Modeling Acute Health Impacts Resulting from Ingestion of Contaminated Drinking Water," Proceedings of the ASCE/EWRI Congress, May 2005.

Uber, James, Lew Rossman, and Feng Shang, "Extensions to EPANET for the Fate and Transport of Multiple Interacting Chemical or Biological Components," Proceedings of the ASCE/EWRI Congress, 2004a.

Uber, James, Robert Janke, Regan Murray, and Phil Meyer, "A Greedy Heuristics Model for Locating Water Quality Sensors in a Water Distribution System," Proceedings of the ASCE/EWRI Congress, 2004b.

Uber, James, Robert Janke, and Regan Murray, "Use of Systems Analysis to Assess and Minimize Water Security Risks," *Journal of Contemporary Water Research and Education*, Issue 129, October, 2004c.

Watson, Jean-Paul, et al., "A Multiple-Objective Analysis of Sensor Placement Optimization in Water Networks," Proceedings of the ASCE/EWRI Congress, June 2004.

TEVA Program Users

Expected users of TEVA include water utilities, consultants, and researchers.

For more information, visit the NHSRC Web site at www.epa.gov/nhsrc.

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November 2005